(12) UK Patent Application (19) GB (11) 2 248 160 (13) A

(43) Date of A publication 25.03.1992

(21) Application No 9118472.1

(22) Date of filing 29.08.1991

(30) Priority data
(31) 87797 (32) 31.08.1990 (33) LU

(71) Applicant
Glaverbel

(Incorporated in Belgium)

Chaussee De La Hulpe 166, Watermael-Boitsfort, B-1170 Brussels, Belgium

(72) Inventor
Marc Dawir

(74) Agent and/or Address for Service
Hyde, Heide & O'Donnell
10-12 Priests Bridge, London, SW15 5JE, United Kingdom

(51) INT CL[5]
H05B 3/84

(52) UK CL (Edition K)
H5H H109 H124 H211 H224 H231 H233 H251 H273
U1S S1917

(56) Documents cited
GB 1529109 A

(58) Field of search
UK CL (Edition K) H5H HAFX HAM HAX2 HBH2 HBH3
INT CL[5] H05B 3/84 3/86
Online databases WPI,CLAIMS

(54) Heatable mirrors

(57) A laminated heatable mirror assembly comprises a mirror coating 3 deposited on a first glass sheet 2 which is laminated by its coated face to a second glass sheet 4 by means of intervening adhesive polymeric material 5, 6.

The mirror comprises two sheets of glass 2, 4 joined by lamination with the interposition of a polymer material. One of the sheets 4 bears a layer 7 conducting electricity insulated from the outer surface of the mirror and extending between current collectors 8, (9). An electric lead (12 figs 1, 3) connected to a collector 8 passes within and surrounded by the polymer material and is extended, within the laminated assembly 1 to the immediate vicinity of the end of another lead (30) connected to the other collector (9) in a single zone of connection (13) to the electrical supply source. The polymer material and conductive layer section is surrounded by electrically insulating material. A seal 20 of electrically insulating material is disposed along the section of the mirror.

The heatable mirror of the invention can be used in particular for auxiliary heating for a bathroom.

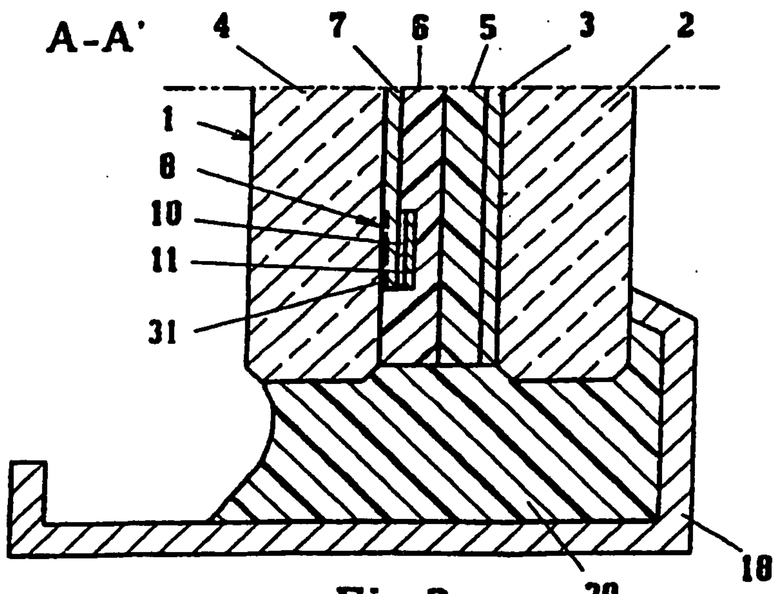

Fig.2

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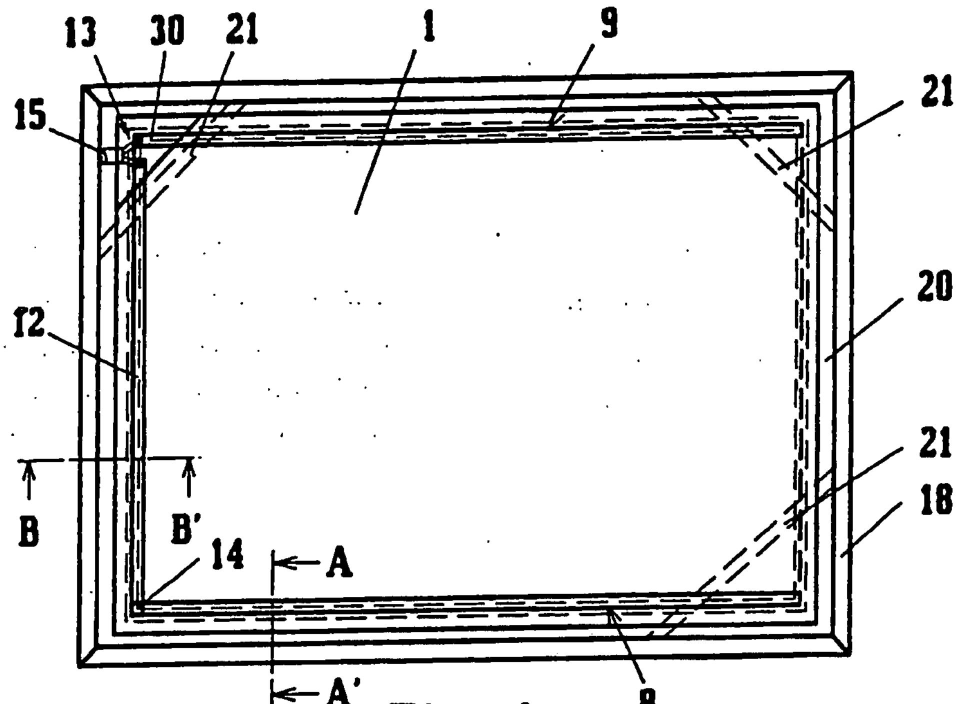

Fig. 1

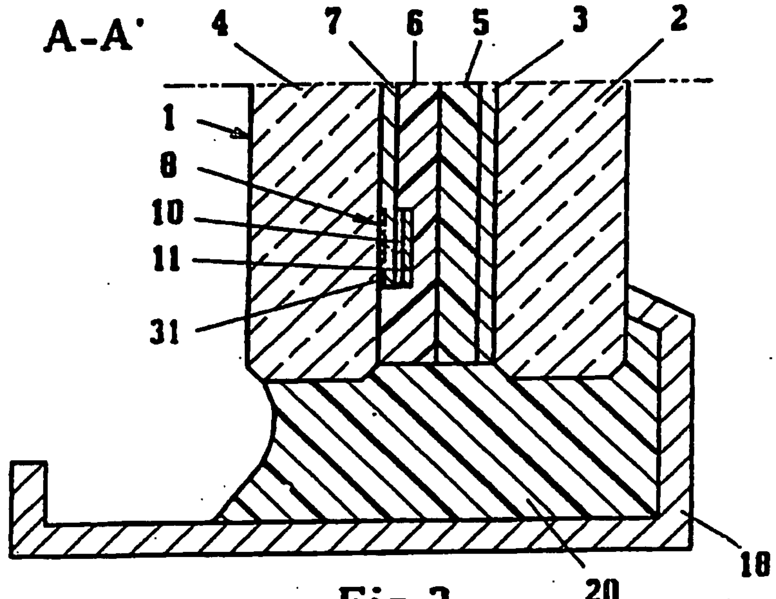

Fig.2

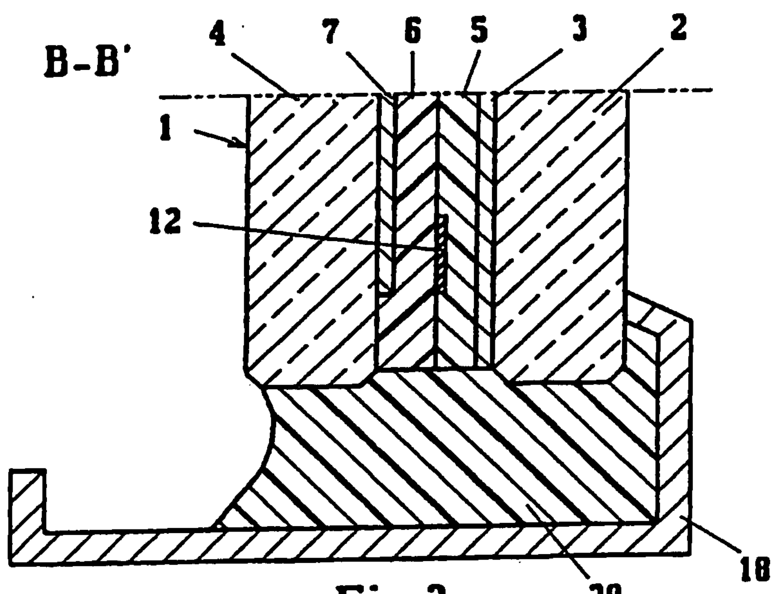

Fig.3

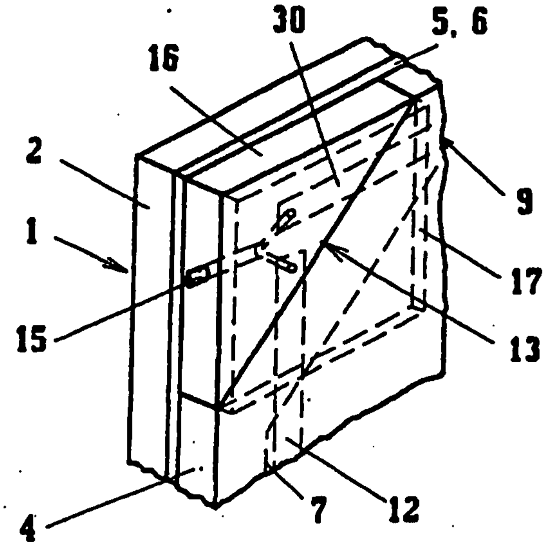

Fig. 4

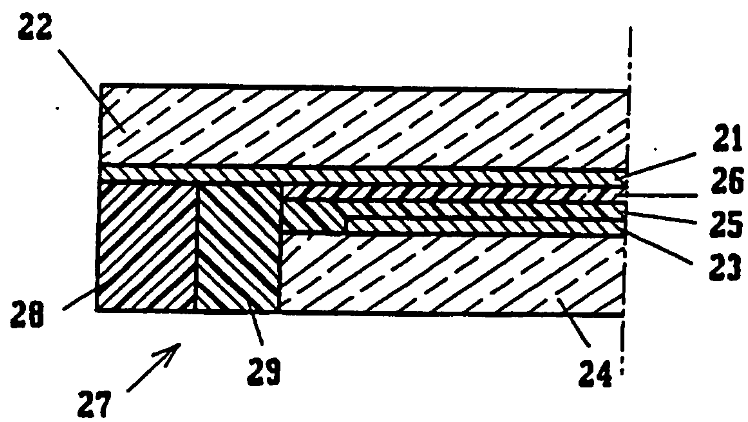

Fig. 5

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JC06 Rec'd PCT/PTO 22 SEP 2005

HEATABLE MIRRORS

The present invention relates to a laminated heatable mirror assembly comprising a mirror coating deposited on a first glass sheet which is laminated by its coated face to a second glass sheet by means of intervening adhesive polymeric material.

Known heatable mirrors comprise a heatable grid which extends over the majority of the surface of the mirror in which the circulation of electric current generates heat by the Joule effect. This heat is distributed over the whole surface of the mirror so that every point of the surface which can be touched is at a temperature which is not too high so as to prevent any risk of burning. Heatable mirrors satisfy two different functions. In addition to their main function of reflecting light rays in the same way as any other mirror, they also give off heat. A conventional example is that of heatable mirrors for bathrooms which give off a slight heat to eliminate the mist which forms on the front surface of the mirror.

When these mirrors are supplied by a source of electric current at very low voltage, for instance 24 V, they do not in practice entail any risk for users and in particular any risk of electrocution. However, supply at very low voltage in residential housing makes it necessary to transform the mains voltage entailing the presence of costly and bulky auxiliary apparatus. Moreover, if the heating power needs to be comparatively high, supply at very low voltage requires the circulation of an electric current of high intensity which raises problems relating to electrical connection and adequate size of the collectors.

The supply of heatable mirrors at the normal mains voltage, for instance 220 V, reduces the intensity of the electric supply current but requires supervision of electrical safety for users. This may raise problems when the heatable mirror has to give off enough heat to bring a room to a comfortable temperature and to operate in a humid environment, for instance a bathroom.

Known heatable mirrors do not satisfy the strict safety standards which currently govern the use of electricity in humid environments.

It is an object of the present invention to provide a heatable mirror which has high-level protection against electric shocks.

According to the present invention, there is provided a laminated heatable mirror assembly comprising a mirror coating deposited on a first glass sheet which is laminated by its coated face to a second glass sheet by means of intervening adhesive polymeric material, characterised in that such second glass sheet is laminated to the first sheet by a face which bears at least one electrically conductive coating layer, there being current collectors connected to such conductive layer(s) and each connected to a conductive lead to constitute a heating circuit for connection to an electrical current supply source, wherein at least one said lead (hereinafter called the "first lead") passes from its region of contact with its respective collector to the immediate vicinity of an end of the other said lead in a common connection zone disposed at the margin of the assembly along a pathway which lies within and is surrounded by the polymeric material, and wherein the polymeric material and heating circuit are surrounded by electrically insulating material.

The heatable mirror of the invention facilitates electrical connection to the supply mains in good safety conditions given that the two supply wires may be connected in the same zone since the connection ends of the two leads are in the immediate vicinity of one another facilitating connection via a single power cord with double electrical insulation. The electric circuit assembly is insulated within the laminated panel. Moreover, the presence of electrically insulating material covering the polymer material section and extending along the periphery of the laminate helps to provide auxiliary insulation. It is thus possible to form an electric heating circuit having a heating surface which is as large as possible with respect to the surface of the laminate and having a double electrical insulation. Moreover, since

the conductive layer and the electric circuit assembly, apart from the connection ends of the two leads, are sandwiched within the laminated assembly formed by the two sheets joined by the polymer material, electrical safety may be preserved even if the sheets are broken as the pieces are held in place by the polymer material.

The term "double insulation" is used in the present description to indicate the presence of independent auxiliary insulation in addition to the operational or main insulation so as to continue to provide protection against electric shocks in the event of the failure of the operational insulation. The operational or main insulation is the insulation needed to ensure the correct operation of the apparatus and to provide users with basic protection against electric shocks.

It is surprising to be able to produce an assembly laminated using conventional techniques with the heating circuit and the electrical supply circuit sealed within the laminate, while providing a laminated mirror having high-level optical and mechanical properties.

It is also surprising to obtain a laminated assembly which does not become delaminated during operating and accelerated aging tests even though it comprises members formed by materials with different coefficients of thermal expansion and a heating surface which is as large as possible.

The arrangement of the path of the lead within and surrounded by the polymeric material facilitates electrical insulation in particular from the reflective coating of the mirror which is also electrically conductive. Also, this arrangement of the path of the lead facilitates the lamination of the sheets to form the mirror.

The connection zone designed for electrical connection may be, for instance, in the centre of one of the sides of the mirror if the latter has a polygonal shape. The mirror may also be circular in which case the connection zone is located at a point of the circumference. However, the mirror is preferably rectangular, the collectors extending along two opposite sides of the rectangle and the connection zone is

located in a corner of the mirror. By means of a simple electric circuit, only the first lead has to pass through the polymer material and follow a comparatively long path within the laminate so as to transfer the electrical current between the corresponding collector and the connection zone, as one end of the other collector may terminate directly in the vicinity of the corner so that its corresponding lead may be very short.

In this embodiment, at the location of the connection zone, the corner of one of the glass sheets is preferably cut to allow the passage of the supply wires and the connection of these wires to the leads is embedded in an insulating material. Electrical connection is thus facilitated and a double electrical insulation of the connection terminals may be more readily established with an acceptable aesthetic appearance. A piece of glass covering the insulating material may for instance be attached by adhesive to complete the double electrical insulation.

At least the first lead preferably comprises a flat metal strip, which is advantageously a strip of Cu, allowing the passage of a high electric current intensity without being so thick as to interfere with the connection of the glass sheets. The collectors may be formed by means of a conductive lacquer, for example a silver lacquer deposited by silk screen methods, and the lead formed by the Cu strip may be brought into electric contact with this conductive lacquer. A slot may be provided in the film of polymer material so that the Cu strip can be passed through it before the lamination operation.

The conductive layer may be deposited uniformly over the whole surface of a glass sheet and, to facilitate the electrical insulation of the laminate sections, a groove may be provided along the entire periphery of the conductive layer, for instance 5 mm from the edge, so as electrically to insulate the marginal portion of the remainder of the layer. It is preferable, however, for the surface of the sheet bearing the conductive layer to have a marginal zone of more than 5 mm with no

conductive material, extending substantially along its entire periphery. Very good electrical insulation of the laminate section is thus more readily achieved and maintained over time, especially in a humid environment. A marginal zone of up to, for example, 2 cm having no material conducting electricity may advantageously be left over the whole periphery of the sheet. To this end, the conductive layer may be deposited uniformly over the entire surface of the sheet and the marginal portion then removed, for instance by means of an abrasive wheel. A mask may also be disposed on the marginal portion of the sheet prior to the deposition of the layer, for instance by atomization. This mask prevents the layer from forming on the glass at the location at which it is placed: it is formed, for instance, by an adhesive tape or paint which flakes off under the action of heat.

It is preferred, however, that the conductive layer extends to within 2 cm of the edge of the mirror substantially along its entire periphery. This is especially so in the case of heatable mirrors with rather high-rated heat outputs since it helps to avoid subjecting the margins of the mirror to thermal shock due to high temperature gradients.

The conductive layer may for example be formed by a layer of doped tin oxide. The doped tin oxide may form, on a glass sheet, a very hard heating layer which is readily obtained by pyrolysis in a known manner. This layer is very resistant to handling and therefore to the lamination operations. However, pyrolytic coating techniques may in some circumstances have an adverse effect on the planeity of the coated sheet and this could in turn mar the optical properties of the mirror. Such a conductive layer could alternatively be formed by a metal deposited by chemical or electrochemical methods. However, it is preferable that the conductive layer be formed by cathodic sputtering of a metal. Such layer may be formed, for instance, from gold, silver or copper. Such a technique allows the planeity of the sheet to be conserved after coating. Such a technique also allows the

formation of strongly adherent coatings, and such coatings may easily be regulated in thickness so that the resistivity of the coating is easily controlled. For achieving the best corrosion resistance, it is especially preferred to use a gold coating which may for example be up to 30 nm in thickness. In fact a thickness of about 15 nm is very effective. Such a gold coating may be associated with one or more other coatings for conferring special optical or other properties if desired, for example such a gold coating could be sandwiched between two layers of bismuth oxide.

If such a coating is deposited onto a chemically tempered glass sheet, as is preferred, then that sheet can be made thinner while maintaining a given mechanical strength, and this is of benefit in achieving a mirror assembly which is light in weight.

The reflective coating is preferably deposited on a first glass sheet and is formed by a silver- and/or copper-based layer which is electrically insulated from the conductive layer borne by another sheet by means of a heat-resistant protective paint and the polymer material. The heat-resistant paint improves the resistance of the heatable mirror to aging while ensuring the protection of the reflective coating despite the high temperature of the laminated assembly. The paint and polymer material assembly thus ensures adequate insulation of the electric heating circuit.

The two glass sheets have advantageously undergone a treatment to reinforce their mechanical strength. This may be, for example, a heat hardening treatment. These sheets consequently more readily withstand the thermal shock caused by a spray of droplets of cold water onto their surface when the latter is hot, which further improves electrical safety by ensuring that the laminate remains intact. However, the glass sheet bearing the reflective coating is preferably a glass sheet which has undergone a chemical tempering treatment. The glass sheet bearing the reflective coating is the front sheet of the mirror when installed since the main function of a mirror is to reflect light to

create a reflected image, for instance of a face. Chemical tempering provides the glass sheet with a very high impact strength enabling it to withstand any mechanical and thermal shocks. Moreover, chemical tempering may be carried out on a thin sheet facilitating the construction of a lighter mirror, and it is very much less likely to have an adverse effect on the planeity of a glass sheet than a thermal tempering or toughening treatment.

The glass sheet bearing the reflective coating preferably has a thickness of less than 3 mm, for instance 2 mm. This small thickness limits the heat insulation provided by the front glass sheet.

The glass sheet bearing the conductive layer is preferably a chemically tempered glass sheet. This tempering treatment has no adverse effect on the planeity of the glass and thus no effect on the planeity of the mirror.

The mirror of the invention preferably comprises, on its outer surface, on the side which does not reflect light in mirror image form, a layer with low emissivity. As the rear surface of the mirror has a low emissivity, heat losses due to radiation towards the wall to which the mirror is secured can therefore be reduced. Alternatively, or in addition, the mirror may be backed by a layer of thermally insulating material. If a foam material is used, it should preferably be a closed-cell foam so as to resist the ingress of moisture. Extruded polyethylene foam about 1 cm in thickness is suitable.

The mirror section is preferably covered at least partially with electrically insulating and waterproof material to prevent moisture from penetrating between the sheets. This seal improves the resistance over time, in humid conditions of use, of the electrical insulation between the conductive layer and the laminate section. A silicone-based seal may advantageously be used.

In a first embodiment, the mirror of the invention is surrounded by a metal frame, for instance of aluminium or of plastic, for instance PVC. The presence of electrically insulating material along the

periphery of the laminate ensures the double insulation allowing the use of a metal frame, although very particular attention is paid to maintaining a double electrical insulation of the connection zone with respect to the frame. The space between the frame and the laminate section may be utilized to improve resistance to the penetration of moisture as explained below by installing a leak-tight seal at this location.

In a second embodiment, the sheet bearing the reflective coating is larger than another sheet joined thereto, leaving a margin around the whole periphery of the mirror. In this embodiment, the mirror has no frame and may consequently be produced more economically. The margin may be bordered by a rigid self-adhesive foam of plastic material, for instance polyurethane foam, and the space between this border and the laminate section filled with the seal of electrically insulating material, preferably a waterproof material, for instance silicone.

The heating power of the mirror of the invention is preferably greater than 500 W/m^2 and advantageously greater than 700 W/m^2. This heating power makes it possible to use the mirror of the invention for the heating, or auxiliary heating, of a small room such as a bathroom. A power of 800 W/m^2 advantageously ensures this heating without the risk of generating a dangerously high surface temperature in the front surface of the mirror. Adapting the resistivity of the conductive layer to obtain the specific power desired may be readily carried out, depending on the dimensions of the mirror, by adjusting the thickness of this layer for a layer of given composition. The specific conductivity may also be readily modified by modifying the doping if the layer is formed by a semiconductor such as tin oxide. A third possibility is to form the conductive layer pattern-wise so as to restrict the width and increase the length of the heating current flow path. By combining these three adjustment possibilities, it is possible to vary the total resistance of the heating element.

The collectors may be formed by flame atomization of Cu either directly on the glass prior to the deposition of the layer or after the deposition of the layer. At least one of the collectors is advantageously formed by two superposed strips of lacquer conducting electricity between which an edge of the conductive layer is sandwiched. This arrangement makes it possible to obtain a high electric conduction which is maintained over time despite the circulation of a comparatively intense current. Moreover, the conductive lacquer may be readily applied using current silk screen techniques.

The present invention will now be described, solely by way of example, with reference to the accompanying drawings, in which:

Fig. 1 is a partial plan view of the rear surface of an embodiment of the heatable mirror of the invention;

Figs. 2 and 3 are partial cross-sections through the heatable mirror of Fig. 1 along the lines A-A' and B-B' of Fig. 1;

Fig. 4 is a perspective view of a corner of the mirror of Fig. 1 before it is framed and prior to the deposition of the insulating material on the interposed polymer material section;

Fig. 5 is a partial cross-section through a further embodiment of the heatable mirror of the invention.

The heatable mirror shown in Figs. 1 to 4 comprises a laminated assembly 1 formed by a glass sheet 2 bearing an opaque metal coating 3 reflecting light in mirror image form joined by lamination to a glass sheet 4 with the interposition of polymer material formed by two films 5 and 6. It should be noted that the drawings are not to scale. It should also be noted that the two films 5 and 6 of interposed polymer material are shown separately for the purposes of clarity, whereas in the finished laminate these films are in practice welded into a single layer of interposed polymer material. The glass sheet 4 bears a conductive layer 7 extending between two collectors 8 and 9. The collector 8 is formed by a strip of conductive lacquer 10 deposited on

the edge of the conductive layer 7. In the embodiment shown, the first conductive lead is formed by a strip of Cu, one end 11 of which extends over the entire length of the collector 8 and is held there in electrical contact to increase the electrical conductivity of the collector and which is extended in the form of the strip 12 to a connection zone 13. In this embodiment, the connection zone 13 is located in a corner of the mirror. The strip 12 of the first lead passes through the sheet 6 of polymer material at the location shown by reference 14 in Fig. 1 and follows a path located between the films 5 and 6 of polymer material as shown in Fig. 3, i.e. located within the laminate, up to the single connection zone 13. The electrical connection of the collector 8 is thus provided, via the strip 12 of the first lead, in the same zone of connection 13 as the electrical connection of the collector 9. The collector 9 is also formed by a strip of lacquer on which a strip of Cu, extending over the entire length of the collector, has been placed in electrical contact, to increase the electrical conductivity of the collector. This Cu strip is extended in the form of the lead 30 up to the connection zone 13. The electrical supply cord 15 with double insulation comprising two conductor wires is connected to the strip 12 of the first lead and to the second lead 30 in this connection zone 13.

Fig. 4 shows that at the location of the connection zone 13, the glass sheet 4 has a corner cut off to allow for electrical connection. The Cu strip brought into contact with the collector 9 is extended, outside the collector 9, above the cut in the corner of the sheet 4, in the form of the lead 30 so as to allow electrical connection in the connection zone 13. After connection, the recess is filled with an insulating material 16 such as ARALDITE (Trade Mark) which also secures the ends of the Cu strips.

In order to achieve a double electrical insulation, a small glass sheet 17 of a thickness of 4 mm may be glued above this zone 13.

In the embodiment of Figs. 1 to 3, the laminate 1 is surrounded by a frame 18, for example of aluminium or PVC, and the space

between the section 19 of the laminate 1 and the frame 18 is filled with an electrically insulating and waterproof adhesive material 20, for instance silicone. For the purposes of clarity in the drawing, this insulating material 20 has not been shown in Fig. 4. Connections 21 allowing the mirror to be fixed to a wall have also been shown in Fig. 1 in dashed lines.

By way of specific example, the sheet 2 is a glass sheet with a thickness of 2 mm which has undergone a chemical tempering treatment. The reflective coating 3 is formed by silvering in a known manner and comprises a layer of silver, a layer of copper and a layer of protective paint. In this specific example of the invention, the protective paint is a heat-resistant thermosetting paint sold under the Trade Mark TRIGANITE and marketed by the company "Pearl Paint". The polymer material is formed by two films 5 and 6 of PVB having a thickness of 0.38 mm. The sheet 4 is a glass sheet having a thickness of 4 mm. The conductive layer 7 is a doped tin oxide layer of a thickness of approximately 70 nm ~~obtained by pyrolysis.~~ The conductive lacquer 10 is a cold hardening silver-based lacquer. In order to improve the electrical conductivity of the collectors, a strip 31 of oven-fired silver-based lacquer (shown in dashed lines in Fig. 2) may be deposited before depositing the gold layer. At the location of the collectors, the SnO_2 layer is thus sandwiched between two strips 10 and 31 of conductive lacquer. In this case for example, two strips of conductive lacquer are deposited by silk screen methods on the glass sheet 4 at the location of the collectors and this glass sheet is heated in an oven. The conductive lacquer is fired. On discharge from the oven, the SnO_2 layer is deposited and the glass sheet is cooled rapidly by cold air on discharge from the oven, so as to give a heat-toughened glass.

The strips of cold hardening conductive lacquer are then deposited and the Cu strip is applied before carrying out the lamination operation.

In this specific example, the laminate 1 is a rectangle of 1183 mm by 683 mm, the resistivity of the heating layer is 143 Ω/□ and its total resistance is 82 Ω. The specific heating power of the layer is 800 W/m^2 and the power dissipated by the laminate 1 is 600 W. The temperature of the front surface does not exceed 60°C. To prevent this temperature from being exceeded accidentally, a temperature limiter (not shown) may be provided. This may be embodied in a small plastic housing of 50 x 50 x 15 mm, with double electrical insulation, containing a bimetallic strip which cuts off the electric current supply circuit, for instance at 60°C, and re-establishes it, for instance at 40°C. This housing is glued to the outer surface of the glass sheet 4 in the vicinity of the connection zone 13. The supply cord 15 is connected to this housing and this housing is connected to the mains current supply.

The glazing of this embodiment has successfully passed the safety tests for electric heating systems operating in humid atmospheres and in particular the insulation resistance and dielectric strength test at a voltage of 3750 V.

In a variant of this Example, the glass sheet 4 is a sheet of chemically tempered glass and it is 2 mm thick. The conductive layer 7 comprises three strata: an undercoating of bismuth oxide 6 nm in thickness, a gold coating, and an overcoating stratum of bismuth oxide 15 nm in thickness, covering the gold. The thickness of the gold layer is such as to give a resistivity of about 12 Ω/□, about 16 nm. Such a gold coating is deposited on a sheet measuring 1183 mm by 683 mm in two spaced parallel strips, each having an effective area between collectors of about 1150 mm by 330 mm. The strips are linked at one side edge margin of the panel by a common collector, and they are supplied with heating current through two separate collectors each leading along about half of the opposite side edge margin of the panel. The resulting heater again has a total resistance of about 82 Ω. The

collectors 8, 9 are in this case constituted as Cu strips which are glued to the conductive layers using a conductive adhesive, and they are extended, as leads, through the polymer to a common connection zone.

As another variant of the specific example described above, the collectors 8 and 9 are formed by Cu strips obtained by flame atomization of Cu. In this example, the silver-based conductive lacquer is omitted as well as the end 11 of the first lead. The latter is formed by the strip 12 which is a Cu strip soldered to the end of the collector 8.

In the embodiment of Fig. 5, the heatable mirror has no frame. The reflective coating 21 is deposited on a chemically tempered glass sheet 22. The conductive layer 23 is borne by the heat hardened glass sheet 24. The two sheets 22 and 24 are joined by lamination using a polymer material in the form of two films 25 and 26. The glass sheet 24 is smaller than the sheet 22 so as to leave a margin 27. This margin 27 is bordered by a strip of self-adhesive polyurethane foam 28 and the space between the strip 28 and the section of the sheet 24 is filled with an electrically insulating and waterproof adhesive material 29, for instance silicone.

This embodiment also successfully passed the electrical insulation tests for humid environments. Its structure is lighter and it satisfies the demand, in terms of appearance, for mirrors without frames.

The embodiments shown in Figs. 1 to 5 show a preferred solution in which the conductive layer 7, 23 has an area smaller than that of the sheet 4, 24 which bears it. The conductive layer section is thus insulated both by the interposed polymer material and by the leak-tight sealing material 20, 29.

CLAIMS

1. A laminated heatable mirror assembly comprising a mirror coating deposited on a first glass sheet which is laminated by its coated face to a second glass sheet by means of intervening adhesive polymeric material, characterised in that such second glass sheet is laminated to the first sheet by a face which bears at least one electrically conductive coating layer, there being current collectors connected to such conductive layer(s) and each connected to a conductive lead to constitute a heating circuit for connection to an electrical current supply source, wherein at least one said lead (hereinafter called the "first lead") passes from its region of contact with its respective collector to the immediate vicinity of an end of the other said lead in a common connection zone disposed at the margin of the assembly along a pathway which lies within and is surrounded by the polymeric material, and wherein the polymeric material and heating circuit are surrounded by electrically insulating material.

2. Heatable mirror according to claim 1, wherein the mirror is rectangular and the collectors extend along two opposite sides of the rectangle and wherein the connection zone is located in a corner of the mirror.

3. Heatable mirror as claimed in claim 2, wherein at the location of the connection zone, the corner of one of the glass sheets is cut to enable the passage of current supply wires and the connection of these to the leads is embedded in an insulating material.

4. Heatable mirror according to any preceding claim, wherein at least the first lead comprises a flat metal strip.

5. Heatable mirror according to claim 4, wherein at least the first lead comprises a flat copper strip.

6. Heatable mirror according to any preceding claim, wherein the surface of the sheet bearing the conductive layer has a marginal zone of more than 5 mm with no conductive material, extending substantially along its entire periphery.

7. Heatable mirror according to any preceding claim, wherein the conductive layer extends to within 2 cm of the edge of the mirror substantially along its entire periphery.

8. Heatable mirror according to any preceding claim, wherein the conductive layer is a layer of gold.

9. Heatable mirror according to any preceding claim, wherein the reflective coating is deposited on a first glass sheet and is formed by a silver- and/or copper-based layer electrically insulated from the conductive layer borne by another glass sheet by means of a heat-resistant protective paint and the polymer material.

10. Heatable mirror according to any preceding claim, wherein the two glass sheets have undergone a treatment to reinforce their mechanical strength.

11. Heatable mirror as claimed in claim 10, wherein the glass sheet bearing the reflective coating is a glass sheet having undergone a chemical tempering treatment.

12. Heatable mirror as claimed in claim 11, wherein the glass sheet bearing the reflective coating has a thickness of less than 3 mm.

13. Heatable mirror according to any preceding claim, wherein the glass sheet bearing the conductive layer is a chemically tempered glass sheet.

14. Heatable mirror according to any preceding claim, wherein it comprises, on its outer surface on the side which does not reflect light in mirror image form, a layer having low emissivity.

15. Heatable mirror according to any preceding claim, wherein its section is covered at least partially by electrically insulating and waterproof material.

16. Heatable mirror according to any preceding claim, wherein the sheet bearing the reflective coating is larger than another sheet which is joined thereto leaving a margin over the entire periphery of the mirror.

17. Heatable mirror according to any preceding claim, wherein its heating power is greater than 500 W/m^2 and preferably greater than 700 W/m^2.

18. Heatable mirror according to any preceding claim, wherein at least one of the collectors is formed by two superposed strips of conductive lacquer between which an edge of the conductive layer is sandwiched.

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